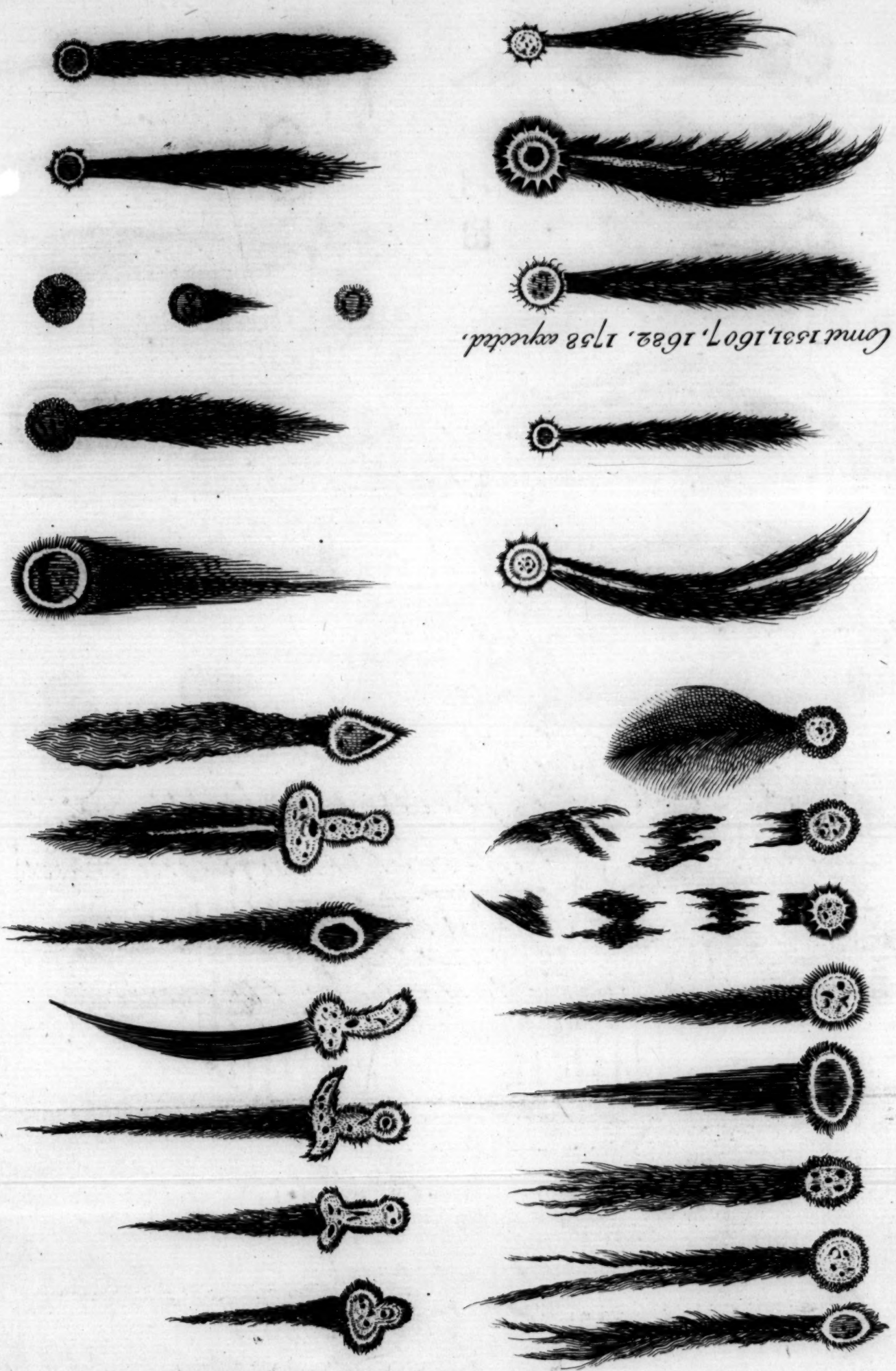


But give me, Goddess, Thou, of Reason
 This Contemplation's calmer Season
 Tranquillity of Spirit clear
 To mark the Path of every Star.
 What Jagers pick'd of Hatter, love
 The Syzygy of Worlds above:
 How never sets the polar Bear:
 The Comet fierce - how came she, there!
 From the Inane, if Art speaks true
 Two Vases attract, it's Centrestro:
 Velocity of dread Emprise
 Alarms the vain, but charms the Wise.
 v. Solitude

Nose

This accounts for its astonishing Velocity & Eclipses is
 forms going round two fixed Stars whose immense distances
 requires some hundred of Years to go round. This is a
 new Hypothesis. but accords so perfectly wth other Phenomena
 as to take Rank for Truth (as it is said) the first Idea is
 claim'd by myself (T.P.) I know of no other P.

*A Representation
of some of the Different Shapes in which
COMETS
And their Tails have appeared*



85606

A
DISCOURSE
ON
COMETS.

Containing, a brief Description of the True
SYSTEM of the WORLD,
AND

An Enumeration of all the DISCOVERIES which
have been yet made concerning those TEMPORARY
APPEARANCES,

With respect to their

ORBITS,		MAGNITUDES,
FORMS,		DISTANCES,
VELOCITY,		TAILS, &c.

Particularly that whose Return is expected in this
or the following YEAR.

Extracted from the Writings of

SIR ISAAC NEWTON,
and other Astronomers.

To which is added,

The Opinion of that illustrious Author, concerning
the Use of COMETS, the Origin of MATTER; and his
Definition of the SUPREME BEING of the UNIVERSE.

Collected by J. L. COWLEY, MATHEMATICIAN.

“ The time will be, when posterity will wonder, that we
“ were ignorant of things so plain: one will arise, who will
“ demonstrate in what regions of space the comets wander;
“ why they recede so far from the other planets; how great,
“ and what sort of bodies they are.”

SENECA.

L O N D O N :

Printed for the AUTHOR, at the ACADEMY, in
BELL-SAVAGE-YARD, LUDGATE-HILL;

And sold by J. PAYNE, at POPE'S-HEAD,
in PATER-NOSTER-ROW,
MDCCLVII.



INTRODUCTION.

 **H A T** my readers may not be disappointed in their expectations, with respect to the following sheets; I here previously declare, that this little tract has no pretensions to enlarge, or advance, any thing farther on this subject, than what astronomical writers have already obliged the world with: all that is here presumed, is only a short extract of the principal discoveries, which have been hitherto made, relating to the true system of the world, and particularly of those temporary appearances, commonly called blazing stars, as comprized in the writings of Sir Isaac Newton, and other astronomers, delivered as free from mathematical expressions as possible; chiefly meaning, to render the perusal hereof, familiar to such as are not qualified to comprehend those authors, who have more properly explained the planetary phenomena; hoping hereby to remove and obliterate those groundless fears, and mistaken notions, which minds unacquainted with a true idea of those appearances, are apt to imbibe. Wherefore, this little piece is to be considered only as a collection of the real advances and improvements, which have been made in this part of astronomy. To
promise

ii INTRODUCTION.

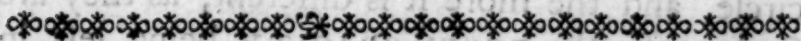
promise any thing more on this subject, would be deceiving the reader, by persuading him to expect what is not possible to be effected at this time. The lights which have been lately thrown upon the science of astronomy, have greatly contributed towards its growing to a perfect state of maturity: but the cometary motions are such, that we cannot as yet expect to see this part of astronomy in that perfection, which we may reasonably hope will be accomplished by the industry of succeeding astronomers, guided in their enquiries by the Newtonian doctrine.

The observations which have been already made, concerning those bodies, and the nature of their motions, are sufficient to engage us, upon very rational principles, in a belief, that astronomers in future ages will as readily predict the time of a comet's appearance, as eclipses are now foretold in these our days: but by reason of the causes hereafter mentioned, it will necessarily require a long space of time, before this part of the science can arrive to so great a degree of perfection; and, perhaps will hardly ever attain to that exact precision of time, to which the prediction of eclipses is now arrived: but as to our ever being able to foretel what they portend, or to assign any time when the events shall happen, of which they may be thought productive, any further, than what is hereafter set forth, does not appear at all likely to come more within the sphere of an astronomer's

INTRODUCTION, iii

mer's prophetic spirit, than is now in the reach of natural philosophy, to assure us, where, or when, the next earthquake shall effect our earth.

In treating on a subject of this kind, some few technical terms belonging to the astronomical science will naturally, and as it were, unavoidably occur; but that these may prove no hindrance to the reader in perusing and understanding what is contained in the following discourse, I thought it convenient to prefix a little GLOSSARY, or explanation, of all such words, which seemed to me a little out of the way of those who have not made astronomical writings their entertainment; their information being principally the motive, that gave birth to the following sheets.



THE

GLOSSARY.

APHELION, APOGEE, APOGEON, are terms which signify that point of the orbit, in which the planet, or comet, is at its greatest distance from the sun.

PERIHELION, PERIGEE, PERIGEON, signify that point which is nearest, or at the least distance from the sun.

MEAN DISTANCE, is that point of the orbit, in which the planet is equi-distant from the APHELION and PERIHELION points; and here the reader is to observe, that in the distances hereafter mentioned of the sun, earth, moon, and other planets, it is the MEAN DISTANCE, which is signified.

ECCENTRICITY, signifies the distance between the sun, and the center of the orbit, which the planet describes about the sun.

ELLIPSIS, is a curve line, somewhat resembling the out-line, or circumference of a circle, but differs particularly in this respect; the circle is described from one center, but the ELLIPSIS has two: now, as these two centers are nearer together, the more the ELLIPSIS resembles a circle, and the more it is different, as they are farther off, the ECCENTRICITY being less in the former case, and greater in the latter.

The two centers of an ELLIPSIS, are called its FOCUSSES, or FOCII.

The longest diameter of an ELLIPSIS, is called TRANSVERSE DIAMETER; and a line crossing it perpendicularly in the middle, is called the the shortest, or CONJUGATE DIAMETER.

The point where the TRANSVERSE and CONJUGATE DIAMETERS intersect each other, is the common center of the ELLIPSIS.

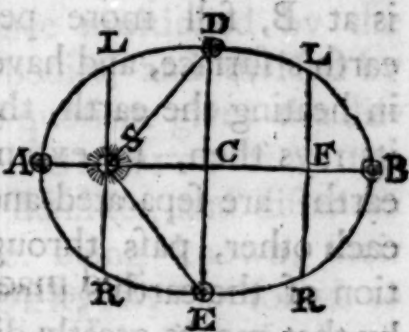
A line

The GLOSSARY.

v

A line drawn through the FOCUS perpendicular to the TRANSVERSE, is called the LATUS RECTUM, or right parameter; it is also called the AXIS.

To illustrate this more plainly, let the CURVE LINE, A D B E, represent the orbit, or track in the heavens, described by a body moving round the sun, at S. Then is, S C, the ECCENTRICITY of that orbit. S and F, are the FOCI. A B, the TRANSVERSE DIAMETER. E D, the CONJUGATE. C, the common center of the orbit. A line drawn from S to D, or E, expresses the MEAN DISTANCE. L F R, and L S R, are each the LATUS RECTUM, or parameter of that orbit. The whole space, comprehended by the CURVE LINE, is called the plane of the orbit.



Thus supposing the CURVE LINE A D B E, to represent the orbit of the earth, and S, the place of the sun; then when the earth is at A, it is in its PERIHELION; when at B, it is in its APHELION; and when at either D or E, is at its MEAN DISTANCE: hence it appears, that the earth is not always at the same distance from the sun; for in December it is nearest

nearest, being then at A, and farther off in June, as at B. Yet notwithstanding, this is no contradiction to what we so constantly experience, of being more affected with the heat of the sun's rays in summer, than what we are in winter: for beside our being exposed in summer to the sun's heat, twice as long as we are in the winter, the sun's rays, when the earth is at B, fall more perpendicularly upon the earth's surface, and have therefore more efficacy in heating the earth, than when in A, because its rays then, by extending obliquely to the earth, are separated and made to diverge from each other, pass through a much greater portion of the earth's atmosphere, and their power by that means greatly diminished.

QUANTITY OF MATTER, is the product which arises by multiplying the density, or weight of any body, by its bulk, or magnitude: thus of two bodies, if one is three times heavier than the other, and four times as big, its **QUANTITY OF MATTER** will then be twelve times as great; but if the density be the same as before, and its magnitude only double, then its **QUANTITY OF MATTER** is only six times greater, or half what it was before.

COMMON CENTER OF GRAVITY, is a point so situated in the right line, supposed to join the centers of two, or more bodies, that its distance from there may be reciprocally proportional to the **QUANTITIES OF MATTER** contained

tained in those bodies: thus, suppose it were required to find the COMMON CENTER OF GRAVITY, between two bodies, whose distance is forty feet, one of them weighing twenty pounds, and the other five, then it will be as twenty-five the total weight, is to forty, the distance, so is twenty; the weight of one body to thirty-two, the distance of the CENTER OF GRAVITY from the other body; or, which is the same, the distance multiplied by the weight of one of the bodies, and divided by the weight of both; the quotient gives the distance of the CENTER OF GRAVITY from the other body. Hence the densities, and distances of the sun, planets, &c. being known, their COMMON CENTER OF GRAVITY is found to be very near where the sun is placed; he is therefore said to be the COMMON CENTER OF GRAVITY, to our system.

DISC, is that flat circular plane, which we observe in looking at the sun or moon; for although they are in reality spheres, or large globular bodies, yet they appear to us as plane surfaces. The diameters of these circular DISCS, astronomers conceive as divided into twelve equal parts, which they call DIGITS, and thereby denominate the quantity of any solar or lunar eclipse.

APPARENT PLACE, is that which any star, or planet, &c. appears to have in the heavens, when viewed by us on the surface of the earth, and

viii *The* G L O S S A R Y.

and differs from that which is its true, or real place, as seen from the earth's center, except when the star, &c. is in the vertex, or point in the heavens, perpendicular to the earth's center.

PARALLAX, or PARALLACTIC ANGLE, is the difference between the true and APPARENT PLACE, of any star, planet, &c. which is nothing at the vertex, but encreases as it comes nearer the horizon; the horizontal parallax being the greatest of all.

HELIOCENTRIC, is a term used to signify the place of a star, planet, &c. as seen from the sun.

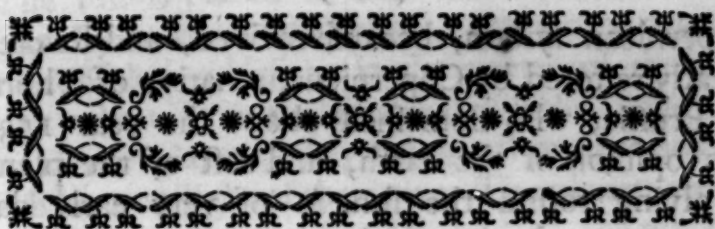
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GEOCENTRIC, signifies the same, only supposes the spectator situated on the earth.

PERIODICAL REVOLUTION, is the time which a planet takes in performing its course round the sun; it is also used for the time of a secondary going round its primary, as the moon round the earth, &c.

4 00 58

SYNODICAL REVOLUTION, is the time which the moon takes, in going from one conjunction to another, this exceeds her PERIODICAL REVOLUTION, upon account of the earth's annual motion round the sun.

A BRIEF



A BRIEF
DISCOURSE
ON THE
SYSTEM of the WORLD,

And particularly the
COMETS.

Y the true system of the world is to
be understood, that which describes
B the earth and other planets, as mov-
ing round the sun, in orbits, which
are elliptical, but so little eccentric,
that their difference from a circle is
not very great ; the sun being the center of their se-
veral motions, and placed in the lower focus of their
orbits. It is sometimes called the Solar system, some-
times the Planetary system ; and sometimes the Py-
thagorean and Copernican system. It is called the
B Copernican

Copernican system, because revived, and its credit greatly restored by Copernicus, a native of Thorne, in Prussia, who flourished about the year 1536: this opinion of the earth, and rest of the planets revolving round the sun, is of very early date, and was taught by Pythagoras, about 578 years before Christ; nor was he thought to be the first inventor, but rather that he learned it of the Egyptians, who were very early observers of the heavenly bodies; and were we to follow the opinion which some learned men seem to entertain, we might attribute its invention to Abraham; who, as they assert, invented and taught the Egyptians the sciences of geometry and astronomy, at the time when he went from Ur of the Chaldees. But however that may be, there are no footsteps whereby it may be traced, as having been so properly explained as it is in these our days.

Not to tire my reader with a description of the several different hypotheses, which have been contrived for accounting for the celestial phenomena, they being now generally exploded, as false and inconsistent, shall rather proceed to give a short description of this system, as explained and demonstrated by Sir Isaac Newton.

This system consists of 16 large masses, or bodies of an opaque terrestrial substance, exclusive of the sun, comets, and fixed stars; are of different magnitudes, at different distances from the sun, and have different periodical revolutions. Those which are nearest the sun, perform their revolutions in the least time, and describe the smallest orbits. And those whose distance is greater, require more time, and describe larger circuits, in exact proportion to their remoteness from the sun, and their quantity of matter. The

The sun is placed so near the common center of gravity to the whole system, that no error arises from considering him as in the center of the planetary orbs. It is the sun that diffuses light and heat to the planets, they being all opaque bodies, which have no light of their own. The planets are distinguished into primary and secondary, the primary revolve about the sun, and the secondary all the while turn round the primary, each attending its own primary planet respectively. The names of the primary planets are Mercury, Venus, Earth, Jupiter and Saturn. Of these there are only the Earth, Jupiter, and Saturn, which have yet been found to have any secondaries attending them: these secondaries are also called Moons, or Satellites. The Earth has only one Moon, or Satellite, revolving round it; but Jupiter has four, and Saturn five: wherefore there are six primary planets, and ten secondary ones.

Mercury is the nearest planet to the sun, and performs its course round him in 87 days 23 hours, which is the length of the year to the inhabitants of that planet, if there be any there, and they compute their time as we do on our earth; its distance from the sun is counted 32 millions of miles; is seldom seen, because of its nearness to the great fountain of light; but often makes transits over the sun's disc; the next visible one at London, will be Nov. 12, 1782, at 44 minutes after 3 in the afternoon; will then appear like a spot upon his surface.

Venus is the next nearest planet to the sun, and makes it round in 224 days, 17 hours; is 59 millions of miles from the sun, and about 22 millions from

the earth. This planet, when on the west side of the sun, is a morning star; but when on the east side, becomes our evening star. On June, 6, 1761, at 55 minutes after 5 in the morning, Venus will make a transit over the sun's disc, and appear like a spot upon his surface, which if clouds do not prevent, will enable astronomers to assign the true distances between the sun and planets to greater exactness than can at this time be boasted of. These two planets, Mercury and Venus, are also called inferior planets, being situated lower than the Earth, and having their orbits contained within the Earth's orbit.

The next higher planet from the sun is our Earth, whose distance is reckoned 81 millions of miles, the time of its revolution round the sun 365 days, 6 hours, nearly, and has besides a diurnal motion round its axis every 24 hours, thereby occasioning our day and night. We have also one moon, which accompanies and revolves round the earth, during its annual progress round the sun, at the distance of 240 thousand miles; performs its synodical revolution, in about 29 days and a half; but its periodical circuit is not quite 28 day.

The rest of the planets are higher up in the heavens, and are therefore called superior planets; of which the nearest to the earth is Mars, whose distance from the sun is 123 millions of miles; is therefore 42 millions of miles higher up in the system than our earth, makes its revolution in one year, 322 days and 17 hours, is only a fourth part so large as the earth.

Next above Mars is Jupiter, whose distance from the sun is 424 millions of miles; the time of its period 11 years 313 days, 15 hours; distant from

from the earth 343 millions of miles ; and has 4 moons or satellites revolving round him at different distances, and different periods. The innermost or nearest to him, performs its course round him, in 1 day, 18 hours, 36 minutes, at the distance of 229 thousand, 150 miles.

The second goes round in 3 days, 13 hours, 15 minutes, at the distance of 363 thousand, 945 miles.

The third moves round in 7 days, 3 hours, 59 minutes, at the distance of 517 thousand 617 miles.

And the fourth, or outermost, in 16 days, 18 hours, 30 minutes, distant from Jupiter, 1 million, 24 thousand, 439 miles.

And next above Jupiter is Saturn, the highest planet that is yet known to our System, goes round the sun in 29 years, 167 days, 10 hours, at the distance of 777 millions of miles from the sun, and 696 millions of miles above the Earth. About this planet there revolve 5 moons ; that which is nearest to Saturn compleats its course in 1 day, 21 hours and 19 minutes, is at the distance of 266 thousand 854 miles.

And the next to that, goes round in 2 days 17 hours, 40 minutes, at the distance of 343 thousand and 99 miles.

The third performs its round in 4 days, 12 hours, 25 minutes, at the distance of 457 thousand, 465 miles.

The fourth goes its period in 15 days, 22 hours, 41 minutes, at the distance of one million, 97 thousand, 917 miles.

And

And the fifth, or outermost Satellite, makes its revolution in 79 days, 7 hours, 48 minutes, at the distance of 3 millions, 293 thousand, 751 miles.

The sun is supposed to be 116 times greater than all the planets put together, and 500 thousand times greater than our Earth. That Jupiter is the biggest of all the planets, even bigger than all the others put together, and 3000 times bigger than the earth; but is yet 160 times less than the sun. The sun contains 1033 times more matter than is contained in Jupiter. Saturn is 400 times less than the sun, and its quantity of matter 2400 times less. Venus and the Earth are much of the same magnitude with each other, but Mercury and Mars are each of them less.

The secondary planets were unknown to astronomers till about the year 1610, when those belonging to Jupiter were discovered by Gallileus, who first invented the Telescope; afterwards Mr. Huygens, in the year 1655 discovered a satellite belonging to Saturn, which is now reckoned the fourth; and afterwards, about the year 1671, *Cassini* discovered the first, second, third and fifth.

The motions of the planets, both primary and secondary, as now explained and demonstrated from the Newtonian principles, have all the graces of harmony and simplicity; the whole system being actuated and governed by one universal and immutable law. The primary planets revolve round the sun in such a manner, that *the squares of their periodical times are proportional to the cubes of their mean distances from the sun*; the same likewise obtains among the secondaries, with respect to the primaries

primaries, which they regard as the center of their motions.

These bodies are acted upon, by two distinct and opposite powers, one endeavouring to draw them towards the sun, which is called their central or centripetal force; and the other at the same time urging them to recede therefrom, called the repulsive or centrifugal force; and these two powers are so duly proportioned as to preserve and retain them in their orbits, in which they freely move with wonderful regularity and rapidity.

Mercury is said to move at the rate of 96 thousand 322 miles in an hour; Venus at the rate of 68 thousand 776; the Earth 58 thousand and 80; Mars 46 thousand 762; Jupiter 25 thousand 543; and Saturn at the rate of 18 thousand 910.

It is supposed that if the centrifugal force were taken away, and the planets left entirely to the action of the centripetal power, they would all be drawn into the sun, as follows, Mercury in the space of 15 days 13 hours; Venus in 39 days 17 hours; the Earth in 64 days 10 hours; Mars in 121 days; Jupiter in 290; and Saturn in 767, or little more than 2 years.

Besides the opaque bodies already spoken of, the firmament of heaven is wonderfully bespangled with an infinite number of stars. If we consider the stars only as being the most remarkable and as most frequently visible, such as astronomers have distinguished into six different magnitudes, whose latitudes, longitudes, declinations, and right ascensions, &c. are determined, we shall find, that by the most enlarged computations yet made, their
number

number is little more than 3 thousand; but if we consider them with respect to their absolute number, we cannot but allow that they exceed the bounds of human comprehension. The telescope discovers a vast number of stars invisible to the naked eye. In only the space between the girdle and sword of *Orion*, at least 80 stars have been seen, and taking in about a degree's space of the constellation, there's above 500, so that in the whole constellation there is, according to Gallileus, at least 62 thousand 5 hundred stars, altho' the naked eye cannot discern above 63. And 'tis very rational to believe, that the galaxy or milky way, is only an assemblage of a prodigious number of stars; but arguments are not wanting, to prove the number of stars more than man can enumerate, when viewed in this light.

Because the stars appear as being always at the same distance from each other, they are said to be fixed, but this appellation is not to be understood as denying them to have a motion peculiar to themselves, but rather as one of the distinguishing characteristics by which they are known from the planets, which are denominated wandering stars, from being at different times at variable distances from each other.

The fixed stars are distinguished into six degrees of magnitude, those which appear the biggest and the brightest are ranked in the first degree, and so on to the sixth; all stars less than those of the sixth magnitude are called telescopic stars, as being to be seen only by that instrument. This difference in the apparent magnitude of the fixed stars, is supposed to be occasioned by their different distances. They are thought to shine each
with

with its own native light, each being of the same nature as our sun, and performing the same office to a system of planets, similar to what we observe in our own. Mathematical knowledge greatly contributes to the strengthening of this conjecture, by its assurances, that if our sun was removed to the same height as the fixed stars, it would appear and be numbered as one of them. Their distance from each other is such, as cannot be conceived, without raising in our minds a most amazing idea of that august magnificence, and infinite wisdom, which is so marvellously conspicuous in all that we contemplate. By the microscope we are astonished at the diminutive size of insects, and their internal organs; so minute are those small productions, that a sudden transition from them to ourselves, creates in us the conceit of being Colossus's of a mighty magnitude; but when we apply the telescope to its proper use, it brings to us such ideas of our littleness, that we can scarce esteem ourselves a visible part of the creation.

When we consider the immense magnitudes, and distances of the fixed stars, we have yet stronger conceptions of our own diminutiveness; for our earth, tho' it be 25,020 miles in circumference, will appear only as a point, if seen from the sun. And, although the diameter of its orbit is 162 millions of miles: and yet it were supposed to be solid, or that the earth were of the same dimensions, it would, even then, appear no bigger than it does now to the sun, if viewed from the nearest fixed star: for they are, at least, 400 thousand times farther from us than we are from the sun, that is 400 thousand times 81 millions of miles. Nor is this to be thought the

utmost extent between the earth and stars; for it so far exceeds our comprehension, that we can set no bounds, either to their number or distance. Huygens has even conjectured that some of them are at so great a distance, that their light has not reached our earth since the creation, and light moves thro' eight millions, 100 thousand miles in one minute, reckoning ten minutes for the time of its passage from the sun to us, which by some is thought to be effected in seven or eight.

But, altho' it is acknowledged that the stars are innumerable, yet we shall deceive ourselves if we think all are stars which seem to present themselves to our view on a clear winter's evening; they indeed appear as such, but 'tis a deception of our sight, which arises from their vehement scintillation and strong twinkling, for when they are viewed distinctly and reduced to a regular order, not one will be seen but what is to be found among the 3000 inserted in Flamsteed's catalogue; for all that are visible to us are there contained, and even some that cannot be seen without a telescope. And it is but very seldom that a good eye can reckon in the heavens more than 80 or 100 together; for if we take a large celestial globe, and compare it with the heavens, we shall rarely see a star there, but what is depicted on the globe.

This imperfect sketch of the mundane system, I think sufficient to persuade us, that to consider our earth as the only habitable planet, would be derogating from those august and magnificent ideas, which the amazing amplitude of the universe must necessarily excite in every contemplative mind: in every part of the creation, there appears an admirable manifestation of infinite wisdom
and

and power; every thing suited to its proper purpose, or as philosophers say, “ nature does nothing in vain;” it cannot therefore be thought consistent with the wisdom of the divinity, to suppose that such a prodigious number of bodies, as we are assured the heavens contain, should be created for no other ends than what may be attributed to our earth.

The great agreement which appears in the substances and other circumstances of the earth, moon, and other planets, renders it highly probable, that they are all likewise inhabited by beings suited to the composition and situation of those respective masses.

The greater degree of heat which Mercury’s vicinity to the sun; or the more intense cold to which Saturn may be subject by its remoteness, beyond what we here experience, is no argument against the conjecture.

History well assures us, that in the more imperfect state of geography, when our planet was less known than it is at present, the greater part of it was thought to be uninhabitable; the torrid zone was deemed too hot, and the two frigid zones too cold; so that only the two temperate zones were allowed inhabitants; but there is nothing of which we are more certain, than that these were wrong opinions. To make beings suitable to inhabit the several planets, or even the sun itself, cannot be thought too hard for omnipotency to effect.

The fixed stars shine with their own native light, and are placed at such immense distances from each other; that they may with great propriety, be
C 2
supposed

supposed so many suns, each affording light, heat, and all the other offices of a sun, to a system of habitable planets, thereby making an infinite number of worlds. To such as have not been accustomed to think any farther of the universe, than as composed only of our earth, with the moon, stars and planets, serving only to enlighten and adorn the expanse of heaven, such philosophical conjectures as these, will probably appear extravagantly romantic and imaginary; but a little excursion into the astronomical science, will in some measure lessen their prejudices, and forbid their condemning them as irrational, at least; especially if they consider that infinite productions are not incompatible; but rather, the necessary consequences of infinite power, we will therefore here conclude, that there are worlds without end; and hence proceed to explain another sort of bodies called comets, that are sometimes observed to appear in our system, which is the chief scope and design of this discourse.

The ancients varied greatly in their opinions, concerning the substance, situation and motions of the comets. Some supposed a comet to be only a meer appearance, made either by the reflection or refraction of the sun's beams, as having no substance real or distinct, from other celestial bodies. Others conceived them to be fiery meteors, generated of copious exhalations drawn from our teraqueous globe; that being elevated to the higher regions of the air, and there taking fire, continued their appearance, so long as the sulphureous matter contained in them continued to burn or shine. And others have imagined, that they were ordained to be of frightful forms, in order to admonish and

and terrify mankind; were therefore looked upon as dreadful presages of some ensuing calamity.

To support those uncomfortable conjectures, all the remarkable occurrences which most immediately succeeded a comet's apparition, were counted as the effects of its baneful influence: thus, the death of the duke of Lorraine; the great war which happened between the Swedes and the Danes, being the most singular events noticed after the comet, which appeared in 1607, were therefore esteemed the effects, or as being foretold by that comet. The same surmises obtained; with respect to other comets which appeared: thus, because Ann, Queen of England, the emperor Matthias, and the empress of Germany died soon after; the deaths of those great personages, were thought to be effected or predicted by ~~that~~ comets. These and many other such instances were collected as corroborative circumstances, for supporting the fancy of considering the comets as ominous messengers of the future evils, or mutations which were to happen on earth: but the vanity of these conjectures, is from experience sufficiently manifest; and observations do abundantly testify, against the verity of this opinion: for wars, famines, pestilences, the death of princes, and other such like remarkable events have happened at such times, as could not with any propriety be imputed to the influence of a comet.

Altho' indeed the ancients were for the most part ignorant of the course and substance of the comets, yet there were some among them that conceived them to be bodies different from the rest of the planets, who supposed them to be placed in the heavenly regions, higher than the moon;

for

for the Pythagoreans and all the Italian philisophers described the comets as a kind of planets or wandering stars, as disappearing, and then after a long space of time, made their appearance again. Aristotle affirms, that Hippocrates Chios, was also of this opinion; and Seneca says, that it was suspected by Democritus, that there were many stars, meaning comets; having their own peculiar motion, but had no knowledge of their number, nor their course in the heavens. And 'tis affirmed, that the Chaldeans reckoned the comets in the number of wandering stars, and that they also knew their courses: and Seneca himself says, " I cannot believe, that a comet is a fire suddenly kindled, but that it ought to be ranked among the eternal works of nature; that it has its proper place, and is not easily moved from thence; goes its course, and is not extinguished, but runs on beyond our sight." To these rational conjectures, he adds this prophetic declaration, " The time will come, wherein those things which are now hid from us, will be discovered; which observation, and the diligence of after ages will find out; for it is not one age that is sufficient for such great matters. The time will be, when posterity will wonder, that we were ignorant of things so plain: one will arise, who will demonstrate in what region of space the comets wander, why they recede so far from the other planets, how great, and what sort of bodies they are.

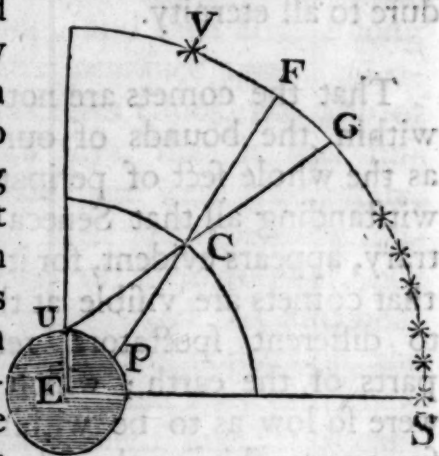
This account of comets is very congruous to that which the moderns have since established; and Seneca's prophecy is fully compleated in the illustrious Sir Isaac Newton, whose accurate labours on the planetary system, aided by the immutable truths of geometry, have founded the science of astronomy

astronomy on such a solid foundation, as shall endure to all eternity.

That the comets are not generated and confined within the bounds of our terrestrial atmosphere, as the whole sect of peripatetics would insist, notwithstanding all that Seneca could urge to the contrary, appears evident, for it is incontestably certain, that comets are visible at the same instant of time, to different spectators residing on very distant parts of the earth; which could not be, if they were so low as to be within the body of air which surrounds this earth, whose height does not exceed 45 or 50 miles at the most. So far is it from being probable, that their situation is so near the earth, that it is plainly demonstrable they are higher than the moon; for if two observers on distant parts of the earth, observe at the same time the distance of the moon, each from the same fixed star, to one of them she will appear as being nearer to that star, than what she does to the other; but if instead of the moon, a comet is viewed in the same manner, its distance will appear as being the same to both spectators; therefore, its altitude in the heavenly regions, is consequently greater than that of the moon. As a farther illustration and proof of this, let the circle U P E, represent the earth. Let U represent the castle of Uraneborgh, P the city of Prague, capital of Bohemia, and C the comet.

These two places differ 60 degrees in their latitude, and a comet was observed from both these places at the same time, by Tycho Brahe, from his observatory then in Uraneborgh, and also by Hagecius, at Prague; both computed its distance from the same fixed star called Vultur, and the distance

distance appeared the same to both, thus; suppose the region of the fixed stars to be represented by the arc $VFGS$; then the comet seen by Tycho at U , appeared among the stars at G , and at the same time being seen by Hagecius at P , its apparent place to him was at F ; in the former case its distance from the Vultur, or star whose place is at V , was the arc VG ; but in the latter, its distance from the same star is defined by the arc VF .



Now the arc VF , is lesser than the arc VG , yet notwithstanding this the comet appeared to both observers, as being at the same distance from V ; therefore, the arcs VF and VG , were apparently equal; the comet's distance was therefore so great, that the arc FG , which is the difference between VF and VG , became imperceptible; wherefore the comet was much higher than the moon, for the moon being observed in like manner, appears to distant spectators at different distances, when estimated from the same star.

Astronomy is now arrived to that degree of perfection, and the celestial bodies and their motions, are so well understood, as plainly evince, that eclipses are no other than ordinary and unavoidable consequences, necessarily resulting from their disposition, and the laws which the divine being has ordained for governing and regulating their several revolutions; and

and that in every annual revolution of the earth about the sun, there must always have been two eclipses at least, occasioned by means of the lunar and terrestrial motions, and that no year can produce more than six; yet such was the state of the astronomical science in former ages, that till the time of Thales, the Milesian astronomer, the true reason of these obscurations was unknown; and the superstition of those times denounced them to be portentous of great and malevolent effects.

These conjectures were carried to great heights; and books wrote pretending to describe the respective parts of the earth, against which the ill effects of any particular eclipse were destined; asserting also, that the effects arising from an eclipse of the sun, continued for as many years as the eclipse lasted hours; but those produced by an eclipse of the moon, were allowed to endure but only so many months, which ill-grounded fallacies are now justly exploded.

Ricciolus in his *Almagest*, relates a story of Columbus, as being drove on shore on the island of Jamaica in 1493, and that being there distressed and unpitied by the barbarian inhabitants, threatened that he would afflict them with a plague; assuring them, as a sign of his power, that on a certain day the sun should be darkened; which by an eclipse was effected on the day he assigned: their ignorance, and his skill in astronomy, proved advantageous to him, and wrought that terror in their minds, as made them vie with each other, who should first and most oblige him.

In such an instance as this, I think Columbus was justifiable; but that the spirit of conjecturing, and promulging fearful divinations, should now

be entertained among us, and the face of science be again covered with a veil of superstition and doubtful hypotheses, grounded on vague and uncertain notions, does not appear to me consistent with the rules of scientific enquiries.

Earthquakes and blazing stars are phenomena which generally spread terror and amazement. The former wherever they are felt produce a consternation; and the latter, whenever they are seen afford such a singular appearance, as affects the spectators with wonder and astonishment. History affords us many, and some of them very recent and melancholy instances, in which the earth has been terribly convulsed, and many of its inhabitants suddenly destroyed; and from similar causes violent and dreadful disasters have been effected by lightning; nor are we without many examples of prodigious calamities, which a boisterous agitation of our atmosphere has often occasioned. These affecting terrors are general incidents, to which, as inhabitants of this earth, we are constantly exposed: and surely they are sufficiently alarming, as not to require an augmentation from any fanciful conjectures, unsupported by either reason or experience.

That comets are not to be considered as destructive, but rather as conservators of the planetary system; created by the great author of the world, for the useful purposes of supplying heat and light, to such other bodies as are, by their remote distance from the sun, in need of such reinforcements, was the opinion of that sagacious astronomer Sir Isaac Newton, and also appears most agreeable to the phenomena, which their motions discover. For those bodies are observed to cross the planetary orbs, in all manner of directions, ascend

ascend beyond the orb of Saturn, the highest planet known to us, and from thence run far into infinite space. They are likewise solid opaque bodies, whose substance is probably similar to that of our earth, moon, and other planets, but exceeding them in their density. That the comets are of prodigious density, is indicated by the nature of the office to which they are assigned: for they being to convey the heat to distant regions, which they receive from the sun, ought to be of sufficient solidity for receiving and retaining heat; and that their density is greatly superior to that of our earth, or any other substance known to us, is sufficiently evident from the great intensity of heat, which they must need imbibe at their approach to the sun; some of them especially, as for instance, the comet which was seen in 1680, was so near the sun, when at its least distance therefrom, as to be within about a sixth part of the sun's diameter from his surface, that is about 102 thousand, 204 miles, and must therefore have been violently heated. The heat which this comet imbibed by its vicinity to the sun, Sir Isaac has computed to be 2 thousand times greater than the heat of red hot iron; the heat of red hot iron, he supposes to be three or four times greater than the heat of boiling water, and the heat of boiling water he computes to be three times greater than that which dry earth receives from the sun in summer. Wherefore the heat acquired by that comet was so intense, as is more than sufficient to vitrify and dispel in vapour, any substance known to our terrestrial habitation. And being thus heated, it will retain its heat a long while, for a globe of iron as large as our earth, being heated till thoroughly red hot, it would be 50 thousand years before its heat would be all evaporated; and

comets are but little less than the earth. The motions of comets are also governed and regulated by laws, which are similar to those, by which the several planets are retained in their respective orbits, are wonderfully regular, and with the greatest freedom traverse the planetary orbs, without suffering or causing any resistance or disturbance whatever.

And it is farther remarkable in the cometary revolutions, that their orbits are so ordained, that when on account of their very slow motion, which they observe at their greatest distance from the sun; they by being there so long detained, might be liable to disturbance, from their attracting or gravitating towards each other; that the harmony of their motions is wonderfully preserved, by their observance of that law which enforces their motion, and diffuses them over distant parts of the wide expanse of infinite space, being there compelled to recede from each other to such distances, as effectually secures them from destroying each other, and that by thus receding to great distances, the only effect which their gravitations may be thought to produce, is only a small acceleration or retardation of their motions, when in those points of their orbits, thereby occasioning some uncertainty in predicting the exact time of their future appearance in our region. But when they descend so low, as to enter the sphere of the planetary orbits, the velocity of their motions is seen continually to encrease, till they arrive at their nearest access to the sun, where their motion acquires its greatest rapidity, and the comet returns again with a very great, but decreasing velocity, appearing slow, as it disappears, in ascending into the higher regions.

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Every comet moves in an orbit, whose plane is peculiar and distinct to itself; wherefore different comets move in orbits which have different planes; but each comet constantly perseveres to move in the plane of its own orbit. They move, as has been observed, in all manner of directions, and in different regions of the heavens; some according to the order of the signs, like the planets, from right to left; others retrograde, or from left to right, contrary to the order of the signs; some from north to south, others from south to north; in short, their paths cross one another in all kinds of directions: but so far as has been hitherto observed, they most chiefly frequent the Zodiac, and scarce ever attain to forty degrees heliocentric latitude.

The comets and their orbits may be distinguished several ways, viz. 1. By observing the course they take in their motion among the stars. 2. By taking their diameters when in perihelion. 3. By noting their position in the heavens, or distance from some known fixed star, when in perihelion. 4. Or they may be known by the proportion which their perihelion velocities bear to each other; for that proportion gives the parameters of their orbits, the parameter being always quadruple the perihelion distance: therefore when a comet is observed to have the same perihelion distance from the same star, an equal velocity when in perihelion, the same course among the stars, and also the same diameter when taken in the same points of its orbit, as one that was formerly observed in these several particulars, they are strong indications that it is one and the same comet: upon these accounts the comet seen in 1661, is supposed to be the same as that which before appeared in 1532; for in all these

these particulars there was a near agreement between them; but till they were thus examined, were generally thought to be two different comets.

By making such observations as these, and comparing together all the dimensions of the orbits deduced from those remarks, the number of comets may at last be determined; but on account of their long periods, astronomers have these opportunities so seldom, that the perfection of this part of the science, must be left to the industry of after ages, and will afford employ sufficient for many ages yet to come.

The motion of a comet being thus observed, it will be no difficult matter to judge of the form of its orbit; for if the comet, when observed at the time and place where it hath the greatest velocity, and at ninety degrees distance on each side of that place, the angular velocity be found at those points to exceed the fourth part of its greatest velocity, then its orbit is certainly an ellipsis, and its periodical revolution will be very short. But if the angular velocity be exactly equal to a fourth of the greatest, or so little differing from equality, that the variation may be reasonably imputed to the inaccuracy of the observation, the orbit is then a very eccentric ellipsis; having its longest or transverse diameter greatly extended, and the time of its period, or return will then be very long.

But because astronomical calculations, grounded upon very eccentric ellipses, are tedious and complex, and as the comets are visible to us during only a very short part of their revolution, and such eccentric ellipses being at their vertices nearly of the same curvature as a parabola; for the parabola
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may be taken as an ellipsis, having its focii at an infinite distance ; it therefore follows, that the visible arc of a comet's orbit, may without any sensible error, be taken as the portion of a parabola.

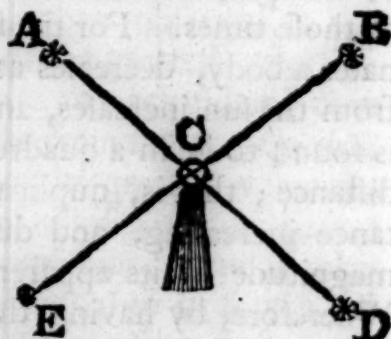
And it is not at all probable that the angular velocity should be less than a fourth of the greatest ; for in such a case, the orbit would be an hyperbola, and the comet would then never more return towards the sun, but be for ever lost to us by its excursion into infinite space.

Comets often descend below the orbs of the inferior planets, when they approach us in their perigees and perihelions ; as is evident from the increase of the splendor which their heads are seen to have at those times. For the sun's light, which illuminates a body, decreases as the distance of the body from the sun increases, and this diminution of light is found to be in a quadruplicate proportion of the distance ; that is, duplicate on account of the distance increasing, and duplicate by reason of the magnitude of its apparent diameter growing less. Wherefore, by having the apparent diameter of a comet, and the quantity of its light, its distance will be found, by taking the distance of the comet, to the distance of a planet, in the direct proportion of their diameters, and the reciprocal subduplicate proportion of their lights.

The diameters of the heads of comets rarely amount to more than 8 or 12 minutes, as far as observations testify ; and the nucleus, or central star, only about a 10th, or 15th part of that, are therefore, generally speaking, of much about the same apparent magnitude as the planets, but their light often equals, and sometimes exceeds that
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of Saturn. It is therefore certain that every comet, when in its perihelion, is either below, or not far above Saturn, therefore they cannot be so remote as the fixed stars, which some have thought; for were they at that distance, they would not then be more illuminated than the planets in our system are by the light of the fixed stars.

The course, or track in the heavens wherein a comet moves, may be easily traced by making choice of four stars, which are round about the comet, and so situated that the comet may be in the right lines which join the two opposite stars; which, by holding a thread before the eye, and extending it over against the stars and comet, is easily effected; as for instance; suppose the place of the comet to be at C, somewhere between the four stars A B D E, and that the line which joins the stars A and D, may pass thro' the body of the comet; and that also the line passing thro' the stars B and E, may likewise pass thro' the comet. This being done in the heavens, extend two threads upon a celestial globe, thro' the stars A and D, and the other thro' B and E; and the point where those two threads intersect, is the place of the comet at this time; and this being repeated daily, will exhibit the comet's course in the heavens, which will be found to be a great circle; for all the points thus marked upon the globe, will be in the circumference of a great circle: and having any two points of this circle, its inclination to the



the ecliptic ; and the places of the nodes may be easily found, by stretching a thread thro' those two points, and observing the point where it cuts the ecliptic.

Or we may otherwise observe its course, by making daily observations of its distance from two fixed stars, whose latitudes and longitudes are known; from those several distances, the respective places of the comet may be calculated, and these places marked upon the globe will shew the course, or path of the comet in the heavens, to be a great circle, except only, the little variation arising from the motion of the earth.

The mistaken notions which the ancient astronomers entertained of comets, in considering them only as meteors, or bodies, compounded of certain combustible matter, collected together in the region of air, and there consuming gradually, occasioned them to think it needless, to be exact in observing their courses ; contenting themselves with saying, that in such a year, appeared a comet of such a magnitude ; passing through such and such constellations : Nor would they, perhaps, have left us even this imperfect account, had it not been for the fiction, which they held of their portending some future fatality. This deficiency of the ancients, in not leaving us accurate observations, of the comets which appeared in their time, occasions the present difficulty, in perfecting this part of astronomy ; no prediction concerning the future appearance of a comet, having been yet verified by experience.

It is yet scarce two hundred years since comets have been properly observed ; in which time all the circumstances attending the motions of about forty

of them, have been discovered; it is therefore no wonder, why the exact time of a comet's future apparition, has not yet been ascertained; for their periodical revolutions are very long, by reason of their very slow motion, when in their aphelions, or greatest distance from the sun. For example: suppose the aphelion distance of a comet from the sun, to be one hundred times greater, than when in its perihelion, then its aphelion velocity, will be ten thousand times less, than when in perihelion; consequently, if the comet when in perihelion, describes, or moves a degree in a day, it will take ten thousand days, or above twenty seven years, to move through a degree when in aphelion: Therefore to determine the exact number of comets, and the precise time of their appearing, is the work of ages yet to come.

The shapes, or forms, which comets have assumed, are very different; for some have appeared in the form of a round dish, of a bright shining silver colour, mixed with gold, or amber colour; and some of this sort have been seen, not perfectly round, but rather resembling a shield. Others resembling a tun; some of an oval form; and some like a barrel set upon one end; some like a horse's mane, varying both in shape and figure; of these Pliny observed some, and described them, as having a very swift motion, and as turning round themselves. Others have appeared like burning lamps, or torches, of several shapes, having their flame, or blaze, sometimes carried upwards like a sword. Some in the form of a dart or javelin; some like a scymitar with a hilt; some like a lance, with its stream of light very long, thin, and pointed. And some having heads, for the most part quadrangular, with a long train, very thick, and uniform.

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In short, they appear under a great variety of forms ; some having beams of light appearing like a beard ; some without any such streams attending them, being in appearance like stars. Very unequal also are they in their magnitudes ; some appearing like stars of the first, or second magnitude, some greater, and some less.

Seneca relates, that in the time of the emperor Nero, a comet appeared, whose magnitude was so great, as to equal that of the sun itself. And Hevelius says, that the comet which was seen in 1652, was apparently as large as the moon, but of less splendor, its light being pale and dim, affording a dismal aspect.

Concerning the tail of a comet, or that long train of light which often attends them, and occasions them to be so much taken notice of, astronomers have formed various conjectures.

Aristotle, and his followers, asserted it to be an exhalation of sulphureous substances, set on fire in the region of the air, there diversifying its appearance, according to the different disposition of the matter composing it.

Peter Apianus, and many others, supposed it to be nothing but the rays of the sun, transmitted through the head of the comet, which he also supposed to be transparent.

And Gallileus imagined the tail to be in its own nature straight, produced by the sun's beams, and that its appearing to us crooked, when near and inclined to the horizon, was owing to the refraction of the visual rays, as being near the earth, replete with gross vapours.

But,

But, Sir Isaac in considering these opinions, observes that the tail cannot be considered as the effect of the sun's light, transmitted through the comet, but by such as are unacquainted with optics: For the beams of the sun are not seen in a darkened room, but in consequence of the light that is reflected from them, by the little particles of dust and smoke, which are always flying about in the air; wherefore in air impregnated with a thick smoke, they appear with greater brightness, but are very faint and difficult to be seen in a fine air, and in the heavens cannot be seen at all, because there is not in the ethereal regions, any matter capable of reflecting the light. Nor can we see light as it is in the beams, but only as it is thence reflected to our eyes; for vision is occasioned only by the rays falling on the eyes, and therefore there must be some reflecting matter in those parts, where the tails of comets are seen.

Again he observes, there are many objections against accounting for this singular appearance by refraction, for the tails of comets are never seen variegated with those colours, which commonly are inseparable from refraction. And the distinct transmission of the light of the fixed stars and planets to the earth, is a proof that the æther, or celestial medium, is not endued with any refractive power; and farther, if the tail was owing to the refraction of the celestial matter, its deviation from the opposition of the sun, should always be directed to the same parts of the heavens, when taken in the same places; but the contrary has been observed, both of the comet which appeared in 1680, and that observed by Tycho Brahe, in 1577; therefore a refractive power cannot be allowed to exist in the celestial medium; but the tails must be derived from

from some reflecting matter contained in the comet's atmosphere.

That vapours may be exhaled by the sun's heat, from the atmospheres of comets, sufficient to fill such immense spaces, to which their tails do sometimes extend, may be easily allowed, when we consider the prodigious and intense heat which some of them receive from the sun; and also, the extraordinary degree of rarefaction, which our atmosphere is capable of. For it is well known, that the air near the surface of our earth, possesses about twelve hundred times more space, than what is occupied by water of an equal weight. By calculations which have been made, it appears, that a globule of air, nearest the earth, of only one inch diameter, if dilated with a rarefaction, equal to that of the air at the height of about forty thousand miles from the surface of the earth, would fill up more space than is contained in the whole heavens, on this side of the fixed stars. Wherefore although we should allow, that the atmospheres of comets, on account of their thickness, may not be so vastly rarefied, yet it is evident, that a very small quantity of air and vapour is abundantly sufficient to produce all the appearances, which are exhibited by the tails of comets; and that their tails are greatly rarefied is plain, from the stars being seen to shine through them: Whereas the atmosphere of the earth, though illuminated by the sun, and of but a few miles in thickness, yet obscures and extinguishes not only the light of all the stars, but even that of the moon; but the smallest stars are seen to shine through the immense thickness of the comets tails, without the least diminution of their splendor, although likewise illuminated by the sun.

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The tails of comets ascend, and are directed towards that part of the heavens which is opposite to the sun; this Kepler speaks of as being effected by the sun's rays, acting on the atmospheres of their heads, carrying along with them the matter which the comet's tail is composed of.

It has been conceited, that in matter there might be two sorts of particles, one endowed with a principle of levity, and the other with the power of gravity; and that the matter composing the comets tails might be of the former, and that their ascent from the sun might be the effect of that levity.

But it is demonstrable, that the gravity of all terrestrial bodies, is as the quantity of matter contained in them, and cannot therefore be either greater or less in the same quantity of matter, wherefore it is more likely that this ascent rather proceeds from the rarefaction of the matter, which composes the tail.

That the tails arise from the heads of the comets, and tend towards the parts opposite the sun, is farther confirmed from the laws which they observe; for lying in the planes of the comet's orbits, which pass through the sun, they constantly deviate from the opposition of the sun, towards the parts which the comets heads have left, in their progress along those orbits. And to a spectator placed in those planes, they appear in the parts directly opposite to the sun; but as the spectator recedes from those planes, their deviation begins to appear, and daily encreases. And the deviation, *cæteris paribus*, appears less, when the tail is more oblique to the orbit of the comet, as well as when the head of the comet approaches nearer to the
sun;

sun ; especially if the angle of deviation is estimated near the comet's head.

Moreover, the tails which have no deviation appear straight, but those which deviate, are bended into a certain curvature ; which is greater as the deviation is greater, and more sensibly seen when the tail, *cæteris paribus* is longer ; for in the shorter tails the curvature is hardly to be perceived. The angle of deviation is greater towards the end of the tail, than it is near the comet's head, and that because the lower side of the tail regards the parts, from which the deviation is made, and which lie in a right line, drawn out infinitely from the sun through the comet's head.

Tails that are longer and broader, and which shine with a stronger light, appear more resplendent, and more exactly defined on the convex side, than on the concave ; and it is also observed, that the nearer the comet accedes to the sun at it's perihelion, the longer is it's tail, and vice versa.

Upon these accounts, it is plain that the tail of a comet, is an appearance that depends upon the motion of it's head ; and not by any means upon the place of the heavens in which the comet is seen ; and that therefore the tail of a comet does not proceed from any refraction in the heavens, but from it's own head, which furnishes the matter that forms the tail.

This is the substance of what Sir Isaac has delivered concerning the tails of comets, which from fundry observations, he concluded to be most consantaneous to truth : But, nevertheless, Mr. Rowning, in treating on this subject, dissents from him in this particular, and gives it as his opinion, that

that when the sun's rays have pervaded a considerable part of the comet's atmosphere, those rays which fall on one side are refracted, or bent towards those which fall on the side opposite; and that by illuminating the vapours contained in it, occasions that part of the atmosphere to be visible to us, which they have not yet passed through, and therefore concludes the tail to be that part of the comet's atmosphere, which is thus enlightened.

Upon the whole, the most prevailing, and indeed the most probable opinion now embraced by astronomers, concerning the tail of a comet is, that it is only a vapour arising from the body of the comet, occasioned by the action of the sun's heat in approaching near it, after having been a considerable time very distant from it, and thereby, in all likelihood, contracted a great quantity of moisture.

To what has been said may be added the following particulars, which have been obtained by the observations of the moderns.

Comets always appear as moving in a great circle of the sphere, and their motions, generally speaking, are similar to those of the primary planets about the sun: In two particulars only, they essentially differ; first, the comets, as has been said, move indifferently towards any part of the heavens, whereas the planets constantly revolve through the same, passing always through the same constellations: And secondly, the comets are visible to us only while they describe a small part of their orbit, as they approach to the sun, and afterwards recede from it; while on the other hand, the planets are visible during their whole revolution,

tion, at least, their orbits are such as admit of a constant visibility, if not obstructed by clouds, or other impediments, incident to the atmosphere of the earth.

Now although the cometary and planetary motions differ in these two particulars, yet that makes no essential argument against their being both obedient to laws which are congruous to each other.

For, first, the impulsive force not being necessarily determined, or confined to any one particular direction, but capable of receiving any, there can be no cause assigned, why it should not act from right to left, from left to right, from south to north, or from north to south, &c.

Now as the position of the plane in which a body moves, with a motion compounded of an uniform impulse, joined to a central force, chiefly depends on the uniform impulsive direction; it follows, that one star may have a different course from that of another, the motive force not being compelled to direct it's impulse one way more than another.

Secondly, if a planet's orbit be so eccentric, that it's diameter when in aphelion, can be seen only under an angle infinitely small; that diameter, and consequently the planet, must be invisible when in aphelion, and will therefore appear only when near its perihelion; because its visibility depends both on its distance from the sun, and its apparent diameter being seen under a visible angle. We may therefore safely conclude, that every one of the comets move in an orbit which is a very eccentric ellipsis, having the sun in its lower focus

and that their velocity is accelerated and retarded by the same law as that by which the planets are governed; and that there is no other theory required for settling the cometary revolutions, than that which is made use of for the planetary system.

That the comets are retained in their orbits, by the conjunction of an uniform impulse, and an accelerative central force, tending to the sun, is manifested by the regular gradations of increase and decrease observable in their motions, as likewise from the concavity of their curve towards the sun, and more particularly from their apparent diameters, velocities, and distances, all which do evidently appear to increase and decrease with wonderful regularity.

The motion of a comet continues to grow swifter, and its apparent diameter increases from the time of its first appearing, until it has described half the arc through which it appears to pass; after which its velocity and apparent diameter gradually decreases, as it goes through the remaining half, the same as it before increased, so that at equal distances from the middle point of the visible arc, the velocities and diameters of the same comet are equal. And the greater the velocity is, with which a comet moves, the greater is the portion of its visible arc, and vice versa.

All comets are not at the same distance from the sun, for those which have a quick motion, approach nearer to the sun than those whose motion is slower. Nor have they a zodiac in the heavens as the planets have: but are permitted to range with various motions, and disperse themselves all over the heavens; and those comets which in their perihelion

helion points descend lowest, move the slowest in their aphelions, and also ascend highest.

It is moreover evident, that the orbit of a comet is not a right line, nor yet a curve, having its convexity turned towards the sun, especially those which describe more than 180 degrees; for it is impossible that an eye should see either a right line, or a convex curve, under an angle of 180 degrees, let its length, or position be what it will, is therefore a curve whose concave part is towards the sun, as has been before observed.

The arcs which some comets appear to describe while visible to us, are only of 80, or 100 degrees, and there are others which describe arcs of 150, 200, and 300 degrees, &c.

Because the comets move in orbits, which are ellipses similar to those of the planets, only vastly more eccentric, it follows that they must consequently have regular periodical returns, and the same comet will be seen several times; also the time of its return, together with the circumstances of its future appearance, may be predicted.

The phenomena of the comets corroborate what has been heretofore alledged concerning the prodigious distance of the fixed stars from the sun; for some of them ascend above ten thousand millions of miles higher than the orb of Saturn, and are yet at that vast distance, nearer the sun than the fixed stars are; for were it not so, they would be attracted and drawn towards the stars, and thereby be prevented from returning again to the sun.

Their motions in the ethereal regions, do likewise invalidate the hypothesis, or notion of the planets

planets being whirled round by the means of vortices, or whirlpools of fluid matter, as maintained by Des Cartes, and his followers ; for the freedom which they enjoy in their several motions in the heavenly regions, going in all manner of directions, is entirely inconsistent with the nature of a vortex.

It is not possible for us to be exact in our judgment, concerning the real uses for which the comets were created ; but the nature of their several motions, by which they dispose themselves all over the heavenly spaces, are strong indications of their being subservient to the useful purposes of enlightning and nourishing the distant parts of the system. It is likewise farther conjectured, that they may be useful in affording a fresh supply of fuel to the sun and stars. We are not without the testimony of several observations, proving that some of the fixed stars sometimes disappear for a while, and afterwards are seen again with more than usual splendor, which gradually diminishing, they by degrees vanish out of our sight : this temporary invisibility of the stars is thought to be effected by the waste occasioned in their substance by the constant emission of their light and vapours, which being recruited by the comets, they are again revived and suddenly appear with extraordinary brightness ; several instances of this kind astronomers have observed in the stars, and were at some loss how to account for this singularity. Some accounted them new stars, but Sir Isaac thinks them to be only old stars, renewed by a fresh supply of matter afforded them by the comets.

He likewise conjectures that the dissipation which the constant emission of light and heat may occasion in the substance of the sun, may be likewise

wife supplied by comets ; and that the comet which appeared in 1680, will by degrees be attracted and drawn nearer and nearer to the sun, at every revolution, till at last it may fall upon and enter into the body of the sun : to this he adds, that the vapours which arise from the sun, fixed stars, and the tails of comets, may at last by the gravity of the planets, meet and fall into their atmospheres, be there condensed and turned into water and humid spirits, and by the means of a slow heat, be gradually converted into salts, sulphurs, mud, clay, sand, stones, and all other terrestrial substances.

The seas are absolutely necessary to the preservation of the constitution of the earth, that the sun may by its heat, exhale from them a sufficient quantity of vapours, to form clouds and distil into rain for watering the earth, and nourishing its vegetative parts ; and which may also be condensed on the tops of mountains, and run down again in streams, forming springs and rivers, and by thus circulating preserve the necessary equilibrium in the seas and fluids belonging to the planets. The decrease which is made in the planetary fluids, by being exhaled in vapours, and spent upon vegetation and putrefaction, and converted thence into dry earth, he supposes to be continually supplied and made up to them by the comets. He moreover suspected, that the finest and most subtle part of our air, upon which our life so much depends, or as some call it the ether, or as others say, the animal spirits, is derived from the comets.

These are some of the uses to which that great man assigns the comets ; but the extreme heat,
prodigious

prodigious density of their atmospheres, and other peculiar circumstances attending them, has incited some to account them as being so many hells, or receptacles created for confining and punishing the wicked. Again, some are for conceiving them as the intended instruments for bringing on a universal conflagration, and have supposed the general deluge to have been effected by a comet. But as those unkind reflections which some have thought proper to bestow on the comets, are not attended with any evidences sufficient to entitle them to be any otherways considered than as meer guesses or conjectures, I shall submit it to the choice of the reader, either to esteem the comets as bodies, created by the divine being, for the comfort and support of the system; or to afflict himself with dreadful surmises, ^{as} he shall think most agreeable; but for my own part, declare, that I esteem the former as the most rational, and as most consistent with the cometary phenomena, the wisdom and beneficence of the divine being.

Of the comet whose return is expected shortly.

Sir Isaac reckons the period of this comet to be about 75 years and an half, allowing it to be the same as was observed in the years 1607, and 1682; which, by the several circumstances attending the observations made at both these times, seems very probable: or, as others assert, has periodical returns of 75 years at one time, and 76 the next, and so on alternately; and must therefore have made upwards of 70 revolutions since the creation, accounting from the Mosaic æra. This comet has a retrograde motion, and according to doctor Halley's accurate computations, in 1607 it described an orbit, whose ascending node was in 20 degrees

degrees 21 minutes of Taurus, and the angle of its inclination to the plane of the ecliptic, was 17 degrees 2 minutes; the time of its being at its nearest distance to the sun, October 16th, at 50 minutes after 3. And since that in 1682, Doctor Halley's computations make its ascending node to be then in 21 degrees 16 minutes and a half of Taurus, the inclination of its orbit to the plane of the ecliptic 17 degrees 56 minutes; the time of its arising to the perihelion, September 4th, at 39 minutes after 7; which computation grounded upon Sir Isaac's Theory, differs from the nice observations of Mr. Flamsteed, only 17 minutes. This comet is described as appearing in the evening, its orbit mostly in the form of a great circle, at last bended a little towards the ecliptic, its head of an unequal roundness, here and there exuberating but its splendor so great that it might, with respect to its light, be compared with stars of the first or second magnitude; its tail somewhat long and thick, projected with a little deviation against that part of the heaven, opposite to the sun, appearing like a flaming sword or lance, about 7 degrees in length.

In 1682, Mr. Flamsteed observed the least apparent diameter of its head, by the micrometer; and found it to be about 2 minutes; but the nucleus or star in the middle scarcely amounted to a tenth part so much; therefore its distance was then about 621 millions, 600 thousand miles from the sun. The aphelion distance of this comet from the sun, is to the earth's mean distance, as 35 to 1; that is, the comet when in aphelion is about 2 thousand, 835 millions of miles from the sun. In 1531, this comet was also seen; the inclination of its orbit to the plane of the ecliptic was then 17 degrees

degrees 56 minutes, and the time of its being in perihelion, was towards the latter end of October.

In the year of Julius Cæsar's death, ante Christi, 44 years, there appeared a remarkable comet in the month of September: and after that again, anno domini 531, when Lampadius and Orestes were consuls of Rome, and again, in 1106 in February, and last of all in December 1680, which had a very long and remarkable tail, only at Cæsar's death, the tail was not so very conspicuous, by reason of the earth's position at that time. The period of this comet is reckoned 575 years, and may be expected again in 2255. It approached very near the sun, was prodigiously heated, &c. as has been observed before.

It is also suspected, that the comet which was seen in 1661, is the same as that which before appeared in 1532.

Among the many comets, which are supposed to be in the world, these three are the only ones, of which we can as yet pretend to form any rational guess, concerning the times of their revolutions or future appearances.

It has been lately affirmed, that if the comet whose appearance is soon expected, should happen to be in its descending node on the 12th of May, that our earth will then be in a dangerous situation, by being involved in the hotter and denser part of its tail.

The history of comets, imperfect as it is, affords us instances of comets having passed near the earth, without effecting any dreadful prodigies of mischief.

And

And Regiomontanus mentions one that appeared very near the earth in 1472. It entered our region the 21st of January, with speed hastened to the sun, with an apparent motion of 40 degrees, in a day; was little more than 30 days in passing to its perihelion from the time of its first appearance; and which owed its extraordinary apparent velocity to its vicinity to the earth. And by what has been already said, it is plain, that the divine being has been observant of the consequences, resulting from the disposition and motions of the several bodies which compose the system of the universe, and displayed infinite wisdom and contrivance in the laws, which are constituted for governing and preserving them, each in their respective courses. Why should it then be thought that this comet, after so many periods, shall this time in particular, prove so fatal a visitant? And why this comet more than any of the rest? It is far from being the largest *, the hottest, or in any other circumstances remarkable above the others, except that the shortness of its period renders its visits more frequent, and that it is the first whose coming is expected from astronomical prophecy. Had the astronomy of comets remained in the doubtful state of former times, we might, indeed, have retained the fears which were then embraced, but should have been utterly incapable of entertaining ourselves with the supposition of enjoying their dreadful effects, on any certain day.

* Comets have been seen apparently as large as the moon.

SIR ISAAC NEWTON's

DEFINITION

OF THE

SUPREME BEING of the UNIVERSE.

THE most beautiful system of the sun, planets and comets, exhibit so many regular motions, as cannot be conceived as the effect of mere mechanical causes, but such as could proceed only from the counsel and dominion of an intelligent and powerful being. This being governs all things, not as the soul of the world, but as lord over all: and on account of his dominion, he is wont to be called Lord God, or Universal Ruler. For God is a relative word, and has respect to servants; and Deity is the dominion of God, not over his own body, as those imagine who fancy God to be the soul of the world, but over servants. The supreme God is a being eternal, infinite, absolutely perfect; but a being, however perfect, without dominion, cannot be said to be Lord God; for we say, my God, your God, the God of Israel, the God of Gods, and Lord of Lords; but we do

do not say, my Eternal, your Eternal, the Eternal of Israel, the Eternal of Gods; we do not say, my Infinite, or my Perfect: these are titles which have no respect to servants. The word God usually signifies Lord; but every Lord is not a God. It is the dominion of a spiritual being which constitutes a God; a true, supreme, or imaginary dominion, makes a true, supreme, or imaginary God. And from his true dominion it follows, that the true God is a living, intelligent and powerful being; and from his other perfections, that he is supreme; or most perfect. He is Eternal and Infinite, Omnipotent and Omniscient; that is, his duration reaches from eternity to eternity; his presence from infinity to infinity; he governs all things, and knows all things that are or can be done. He is not eternity or infinity, but eternal and infinite; he is not duration or space, but he endures and is present; he endures for ever, and is every where present; and by existing always and every where, he constitutes duration and space. Since every particle of space is always, and every indivisible moment of duration is every where, certainly the maker and lord of all things, cannot be never and no where. Every soul that has perception is, tho' in different times and in different organs of sense and motion, still the same indivisible person. There are given successive parts in duration, co-existent parts in space, but neither the one nor the other in the person of a man, or his thinking principle; and much less can they be found in the thinking substance of God. Every man, so far as he is a thing that has perception, is one and the same man during his whole life, in all and each of his organs of sense. God is the same God, always and every where. He is omnipresent, not virtually only, but also substantially;

stantially ; for virtue cannot subsist without substance. In him are all things contained and moved ; yet neither affects the other : God suffers nothing from the motion of bodies ; bodies find no resistance from the omnipresence of God. 'Tis allowed by all, that the supreme God exists necessarily ; and by the same necessity he exists always and every where. Whence also he is all similar, all eye, all ear, all brain, all arm, all power to receive, to understand, and to act ; but in a manner not at all human, in a manner not at all corporeal, in a manner utterly unknown to us. As a blind man has no idea of colours, so have we no idea of the manner, by which the all-wise God perceives and understands all things. He is utterly void of all body and bodily figure, and can therefore neither be seen, nor heard, nor touched : nor ought he to be worshipped under the representation of any corporeal thing. We have ideas of his attributes, but what the real substance of any thing is, we know not. In bodies we see only their figures and colours, we hear only the sounds, we touch only their outward surfaces, we smell only the odours, and taste the flavours ; but their inward substances are not to be known, either by our senses, or any reflex act of our minds ; much less then have we any idea of the substance of God. We know him only by his most wise and excellent contrivances of things, and final causes ; we admire him for his perfections ; but we reverence and adore him on account of his dominion. For we adore him as his servants ; and a God without dominion, providence, and final causes, is nothing else but fate and nature. Blind metaphysical necessity, which is certainly the same always and every where, could produce no variety of things. All that diversity of natural things which we find,
suited

fuited to different times and places, could arise from nothing but the ideas and will of a being necessarily existing. But by way of allegory, God is said to see, to speak, to laugh, to love, to hate, to desire, to give, to receive, to rejoice, to be angry, to fight, to frame, to work, to build. For all our notions of God are taken from the ways of mankind, by a certain similitude, which, tho' not perfect, has some likeness however.

ORIGIN of MATTER.

IT seems probable to me, that God in the beginning formed matter in solid, massy, hard, impenetrable, moveable particles, of such sizes and figures, and with such other properties, and in such proportion to space, as most conduces to the end for which he formed them: and that these primitive particles being solid, are incomparably harder, than any porous bodies compounded of them; even so very hard, as never to wear or break in pieces: no ordinary power being able to divide what God himself made one in the first creation. While the particles continue entire, they may compose bodies of one and the same nature and texture in all ages: but should they wear away, or break in pieces, the nature of things depending on them would be changed. Water and earth composed of old worn particles, and fragments of particles, would not be of the same nature and texture now, with water and earth composed of entire particles in the beginning. And therefore, that nature may be lasting, the changes of corporeal things may be placed only in the various separations, and

SIR

SIR ISAAC NEWTON'S

O P I N I O N

CONCERNING THE

ORIGIN of MATTER.

IT seems probable to me, that God in the beginning formed matter in solid, maffy, hard, impenetrable, moveable particles, of such sizes and figures, and with such other properties, and in such proportion to space, as most conduced to the end for which he formed them; and that these primitive particles being solid, are incomparably harder, than any porous bodies compounded of them; even so very hard, as never to wear or break in pieces: no ordinary power being able to divide what God himself made one in the first creation. While the particles continue entire, they may compose bodies of one and the same nature and texture in all ages: but should they wear away, or break in pieces, the nature of things depending on them would be changed. Water and earth composed of old worn particles, and fragments of particles, would not be of the same nature and texture now, with water and earth, composed of entire particles in the beginning. And therefore, that nature may be lasting, the changes of corporeal things are to be placed only in the various separations, and

and new affociations and motions of these permanent particles; compound bodies being apt to break, not in the midst of solid particles, but where those particles are laid together, and only touch in a few points.

Hence may the reason be assigned, concerning the diversity of bodies. For particles which touch one another by large surfaces, by a mutual attraction of their parts, compose a very hard body. Particles which are not so strongly attracted or entangled with each other, compose a body which is brittle.

If they touch one another in lesser surfaces, then the body is not so hard as the brittle, but may be more solid, if they only approach each other without being one under another, the body is elastic, and will spring to its pristine form; if they slip under each other, the body is soft, and easily submits to any collision, or stroke, as that of a hammer, &c. if they scarce touch one another, 'tis a crumbling body, or one whose parts may be easily separated; if they are small, round, slippery, and easily agitated by heat, it is then a fluid body; if the particles are of an equal surface, and hooked or entangled one with another, 'tis then a flexible or pliant body, &c.

F I N I S.